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Client Reference No.: VTX0053-US

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: CHRIS J. GOODINGS
Confirmation No: 3971

Application No.: 10/035,073
Group No.: 2667

Filed: December 28, 2001
Examiner: Dyke, Kerri M.

For: FRAME STRUCTURE WITH DIVERSITY

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUBMISSION OF PRIORITY DOCUMENT

Attached please find the certified copy of the foreign application from which priority is claimed for this case:

Country	Application Number	Filing Date
United Kingdom	0031812.1	12/29/2000
United Kingdom	0031817.0	12/29/2000

Date: 5/23/2006

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Fo ovation

The Patent Office
Concept House
Cardiff Road
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NP10 8QQ

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o certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an dment, effected by this office, following a request by the applicant and agreed to by the otroller-General.

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E594742-1 D01631
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The Patent Office

Cardiff Road
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1. Your reference — 427076/IML

2. Patent application number *(The Patent Office will fill in this part)* — **0031812.1** — 29 DEC 2000

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   VTECH COMMUNICATIONS, LTD.
   23/F., Tai Ping Industrial Centre
   Block 1, 57 Ting Kok Road
   Tai Po, N.T., Honk Kong

   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of incorporation — ~~Hong Kong~~ 7435001001

4. Title of the invention — Frame Structure With Diversity

5. Full name, address and postcode in the United Kingdom to which all correspondence relating to this form and translation should be sent

   ~~Reddie & Grose~~
   ~~16 Theobalds Road~~
   ~~LONDON~~
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   HASELTINE LAKE
   120 REDCLIFF STREET
   BRISTOL
   BS1 6HU

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   SME 51/77 17/5/01

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application *(If you know it)*	Date of filing *(day/month/year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day/month/year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
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Claim(s)	5
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
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11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 28 December 2000

12. Name and daytime telephone number of person to contact in the United Kingdom — I M LOVELESS 020-7242 0901

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TITLE OF THE INVENTION

Frame Structure with Diversity

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to wireless digital communications. In particular, the invention relates to a data frame structure for use in a wireless communications system which provides improved communications performance under interference conditions.

2. Background Art

The issue is involved with single or multiple handset, frequency hopping radio systems. For simplicity, the discussion in this proposal will be based on a single handset system, but the concepts described will equally apply to a multiple handset system. The discussion is also based on the use of the proposal in a cordless telephone system, but again the application of the proposal is not limited to such a system.

A frequency hopping radio system is one which transmits data (which in the context of cordless phones includes voice traffic) on a series of frequencies. At any one time, only one frequency is used but this frequency changes (hops) in the time domain. The sequence of frequencies used is known as the hop pattern.

Figure 1 illustrates a typical Time Division Duplex (TDD) frequency hopping system by showing the frequency in use as a function of time. The illustration is for a single-handset cordless phone system in which the basestation (BS) transmits to the handset first followed by the handset (HS) reply. The RSSI period at the end of

the frame is used to measure the level of interference on any particular frequency for interference mitigation and is optional. The shaded areas indicate guard bands to allow for frequency and switching settling during which no data transmission can occur.

A significant issue with this type of system is that of interference. This may be on a single (constant) frequency such as would be produced by a non-hopping radio transmitter or is could be generated by a similar hopping system. This situation is illustrated in Figure 2 which shows a time versus frequency plot for two hopping systems and a fixed-frequency system. The system being considered is shown in grey with the interferers shown hatched. Each time the frequency of the system clashes with an interferer, data may be lost with a resultant degradation of voice or data quality. These cases are ringed in the figure.

An important point with this figure is that the effects of fixed-frequency (or slowly time varying) interference can be mitigated against by frequency adaption. In other words, the blocked frequencies would be detected and avoided. However, interference from systems with a hop speed similar or faster than the link in question cannot be avoided by frequency adaption.

DETAILED DESCRIPTION OF THE INVENTION

1. Proposed Frame Structure With Diversity

The proposal which is the subject of this application is to transmit each packet of data twice in successive hops. Thus in each hop there are two transmit slots and two receive slots. This is illustrated in Figure 3. Each frame consists of the following:

- A guard band for PLL settling (shown in grey)
- A transmit preamble
- Transmit data for the current frame
- Re-transmitted data from the previous frame
- A guard band for T/R switch settling (shown in grey)
- A receive preamble
- Receive data for the current frame
- Re-received data from the previous frame
- A guard band for PLL settling (shown in grey)
- Time for RSSI measurement

The key to this proposal is that data is now transmitted twice on successive hops so that there is both frequency and time diversity in the data transmission. The data protocol must contain error detection so that data received correctly can be used in preference to data received in error. This type of scheme can successfully mitigate against fast hopping interference.

In the case of two identical hopping systems with different hop patterns of length n, the probability of the hop frequencies clashing and hence interference occurring is of order 1/n. With frequency diversity in place, the probability of two successive hop frequencies clashing and hence interference occurring is of order $1/n^2$.

The time diversity in the proposed system has the additional advantage that a degree of mitigation will also occur against short-lived wide-band interference.

2. Data Handling in the Proposed System

In the proposed system, identical voice data is transmitted twice in successive frames along with CRC error detection. On receipt of this data, the receiver must make the decision as to which data should be used. An example flow diagram for

this decision process is shown in Figure 4. In this diagram, data being received for the first time is termed D_1 while data being received for the second time is termed D_2.

Initially, the first data transmission is received and it's CRC calculated to see whether the data is correct. If the data has been received correctly on the first occasion, the second data transmission is not required and so any data received during this second period can be ignored. The good data is placed into a buffer (or memory) for later use. However, if the data received in the first slot is incorrect, the second repeat will be required. This is again checked for errors using the CRC encoding. If this is shown to be good it can be placed into the buffer for future use. However, if the second version of the data is also shown to be in error then null data should be placed into the buffer.

Once this process is complete, the data residing in the buffer can be used for further processing and final output. This data will either be the correct data from one or other of the transmissions or it will be null data in the event that both transmissions were corrupted.

3. Power Saving in Frequency Diverse Mode

A key consideration in handheld radio systems is the power consumption since this reflects directly onto the battery lifetime. Clearly, the use of a diverse system such as is proposed will impact the power consumption since data is being sent twice. To put this another way, if the data was only sent once then the radio transmitter and receiver would only be required to be switched on for about 60% of the time (not half due to settle times and preambles).

The concept described above can be extended in order to minimise the impact of the diversity on the power consumption. This should be considered in two stages, the receive and the transmit processes.

With reference to Figure 4, clearly the receiver is aware if the first reception of the data packet is good. Under these circumstances, there is no need to receive the second copy of the data and so the receive path can be powered-down during the time the second copy is being sent. For this to be possible it is important that the second copy of the data from the previous frame is sent after the first copy of the data from the current frame (as shown in Figure 3). Typically this will save a significant amount of power since under normal conditions the data will be received correctly on the first occasion. Assuming that the RF device consumes the same power as the baseband device in the radio system, the battery lifetime could be extended by up to 15% using this technique, depending on the levels of interference present.

While the above-described embodiment in which the redundant transmission of the previous frame's data occurs <u>after</u> the transmission of the new data allows for power savings through strategic deactivation of the receiver, in other embodiments it may be desirable to reverse the order of data transmission. Specifically, buffer memory and computational requirements can be reduced by retransmitting the prior frame's data <u>before</u> transmitting new data. This allows the receiver to choose between the primary and redundant transmissions of any given data, and subsequently pass that data on for processing, before any subsequent new data is received and stored. Thus, by reversing the order of data transmission from that

shown in the drawings, the receiver need not handle multiple different subpackets of data simultaneously.

While reducing the operation time of the receiver can reduce the power consumption of the radio system, substantial reductions in power can also be obtained by reducing the operation time of the transmitter as well, inasmuch as transmitters typically consume greater amounts of power than receivers. Therefore, in some applications of the invention it may be desirable to condition diversity operation upon the satisfaction of an operating condition. For example, a cordless telephone may be designed such that it only transmits the diversity data from the previous frame when channel quality is poor, such as when the error rate exceeds a threshold level. Channel quality could be evaluated, and diversity transmission controlled, for all frequencies in the hop sequence, or for each hop frequency separately. In addition to evaluation of channel quality, the choice between diversity and non-diversity modes may depend upon power reserves available in a battery-operated transceiver unit. For example, as a mobile telephone handset's battery nears depletion, the telephone may switch to non-diversity transmission mode to conserve battery power, thus choosing a communications link with greater error rate over battery depletion and a lack of any communications at all.

Other applications of the invention may incorporate an asynchronous diversity feature, such that improved communications performance is achieved for only one direction of a bidirectional link. For example, in a mobile telephone system in which a fixed base station is capable of transmitting data with substantially greater power than a small, battery-powered mobile telephone handset, data sent with low power

from the handset to the base station may be corrupted by channel interference even while high-powered transmissions from the base to the handset are received adequately. Thus, it may be desirable to implement diversity transmission of data by the mobile handset, along with diversity reception by the corresponding base station, while maintaining the opposite communications link in non-diversity mode.

4. Conclusions

A frame structure has been described which provides both frequency and time diversity. This has the ability to mitigate against both slow and fast hoping interference. The example application described is a cordless telephone although the concepts could be extended to other systems.

Methods for reducing the consequence that the diversity has on the power consumption of the system has also been described.

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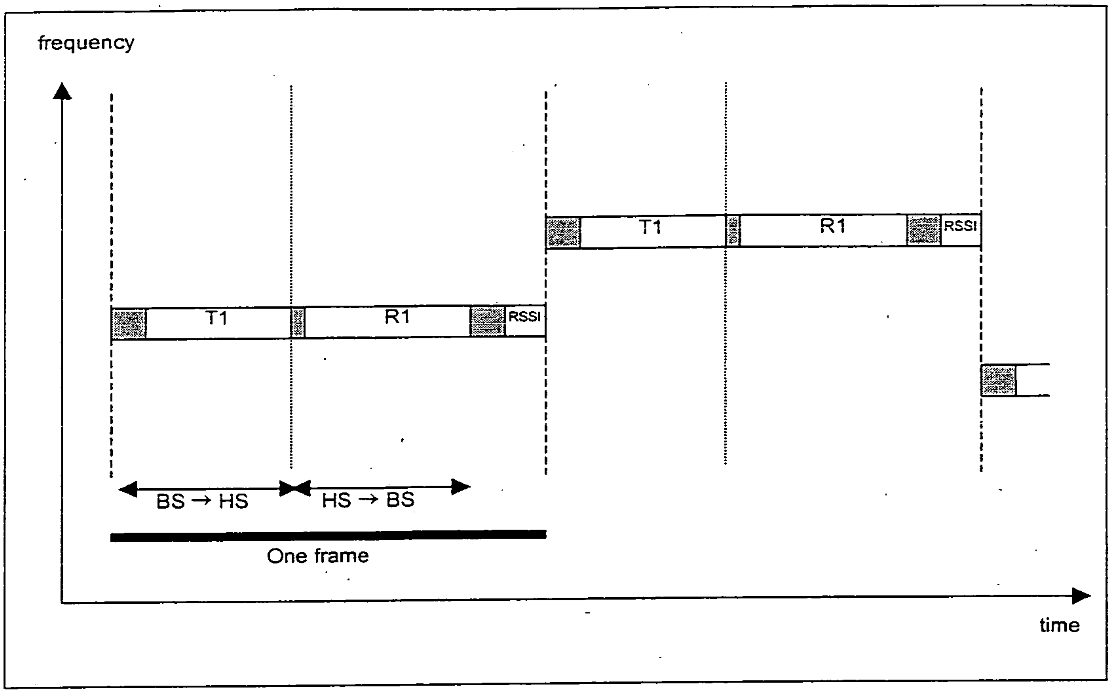

Figure 1 : Illustration of a Single-Handset TDD Hopping System

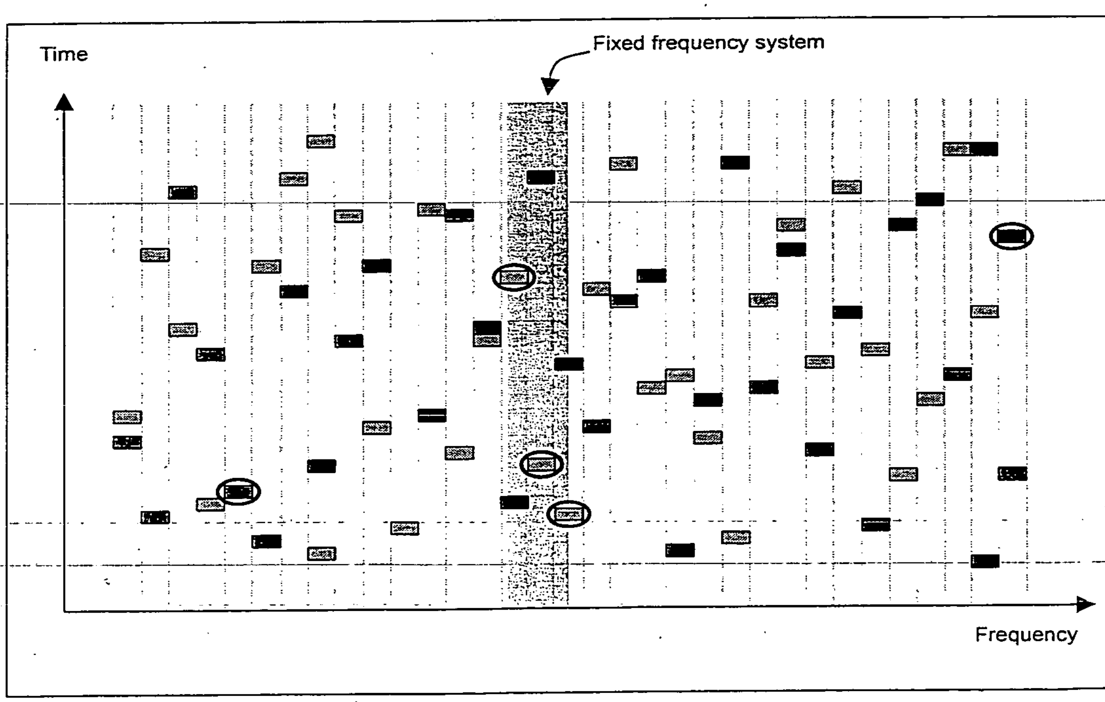

Figure 2 : Illustration of a Hopping System with Interference

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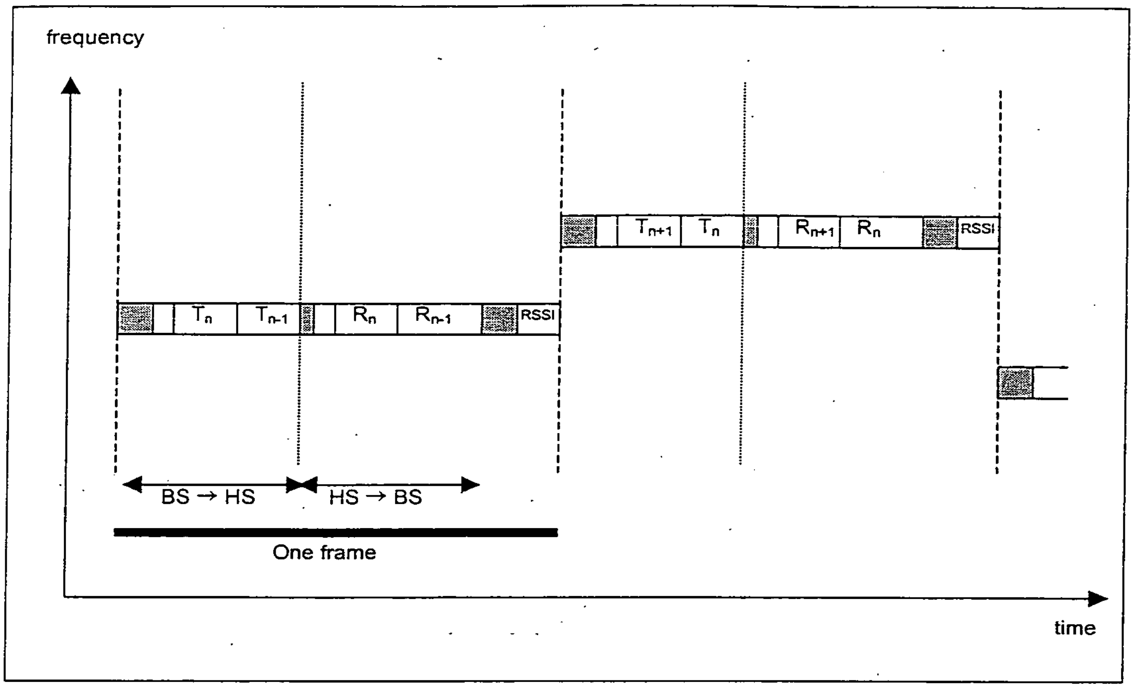

Figure 3 : Illustration of a Proposed Diverse Hopping System

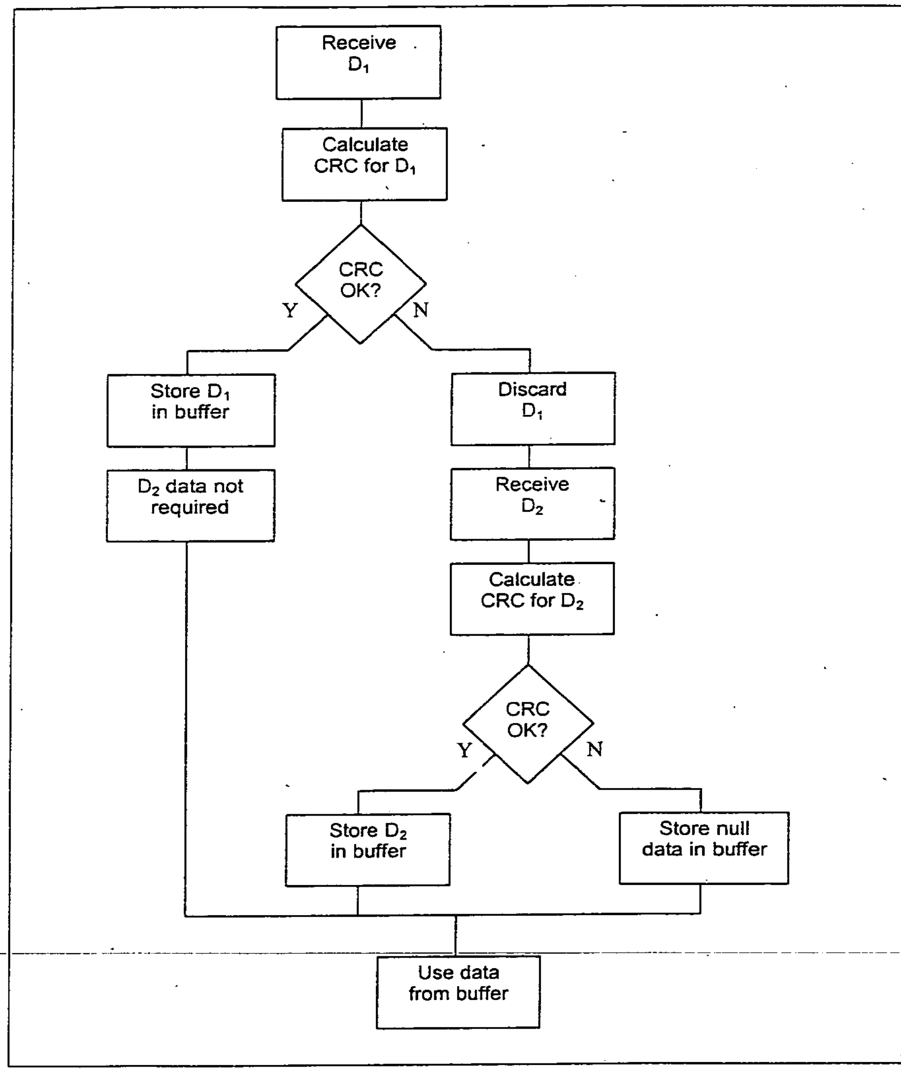

Figure 4 : Example Flow Chart for Data Handling